Head Waves in Asian Marginal Seas

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LONG-TERM GOALS

To develop a robust means to utilize readily-obtained precursor (or head-wave-like) arrival measurements for purposes of geoacoustic inversion.

These arrivals are important features of shallow water propagation that are exhibited at relatively short ranges (< 1 km). They are more directly linked with seabed properties, in contrast to long-range, trapped modal arrivals.

OBJECTIVES

The objective this year was to analyze, model, and invert precursor arrivals measured from the Yellow Sea as part of the August 1996 joint U.S.-China Yellow Sea Experiment [1] using new methods derived the previous year of this grant [2].

APPROACH

The approach involves a combination of ray theory for travel time analysis and simulation using the RAM Parabolic Equation (PE) code. The sound speed profile in the sea bed is estimated from travel time analysis of precursor arrivals. The spectrum of these arrivals is used to invert for compressional wave attenuation in the sea bed. This approach along with additional methods derived in previous year and described in [2] are used to elucidate the nature of the Yellow Sea precursor arrivals.

WORK COMPLETED

The year begin with the PI (Dahl) organizing a special session for the 150th Meeting of Acoustical Society of America in Minneapolis (October 2005) on the subject of head waves, interface waves and geoacoustic inversion. Revision and modification of the manuscript entitled: “First-order and zeroth-

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order head waves, their sequence, and implications for geoacoustic inversion" was completed and this paper was published in the June 2006 issue of the *Journal of the Acoustical Society of America.*

The primary accomplishment for year is summarized in the manuscript entitled: "Precursor arrivals in the Yellow Sea, their distinction from first-order head waves, and their geoacoustic inversion," which has
been accepted to the *Journal of the Acoustical Society of America.* Some results from this work are summarized below.

RESULTS

The key results from work this year pertains to analysis of measurements made during the U.S. and China Yellow Sea experiment (Fig. 1). Data are of the kind depicted in Fig. 2; these are precursor arrivals or pulses that have traveled through the sediment and arrive prior to any contributions that have traveled through the water column. Evidence is presented that these arrivals are zeroth-order refracted waves [2]. Synthetic time series generated using Parabolic Equation (PE) methods are used to support this evidence, and geoacoustic parameters describing a linear gradient in compressional sound speed and attenuation in the seabed are inverted from the data. Since these observations are zeroth order, they relate directly to a positive gradient in sediment sound speed, and an equivalent (or effective) half-space geoacoustic model, although often found to be consistent with the first-order head waves, cannot be identified that is consistent with these observations. Additional details including results of inversion are summarized in the aforementioned manuscript "Precursor arrivals in the Yellow Sea …"

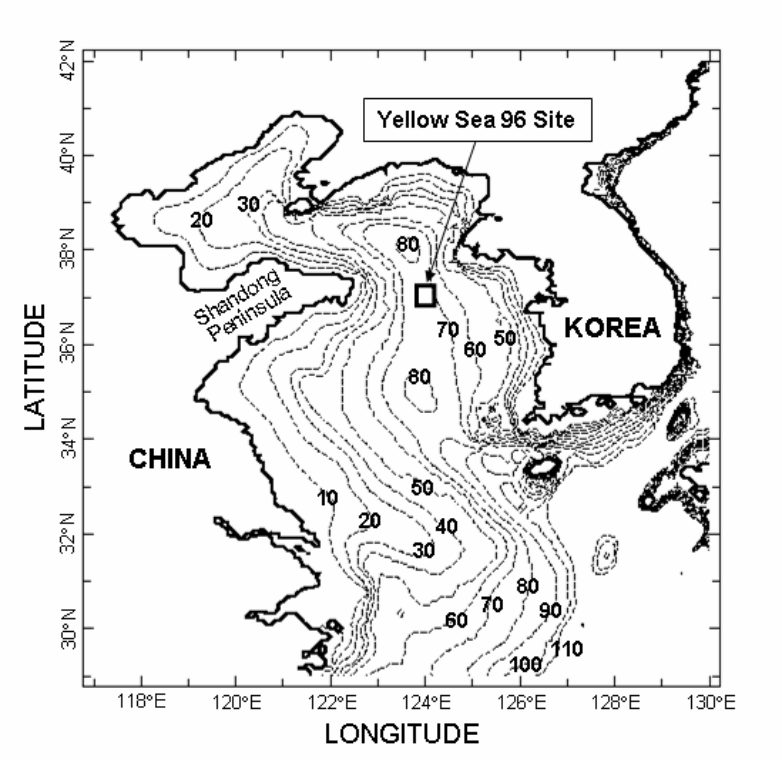

Figure 1. Location of the 1996 Yellow Sea experiment conducted by China and the U.S. including bathymetry contours in meters.

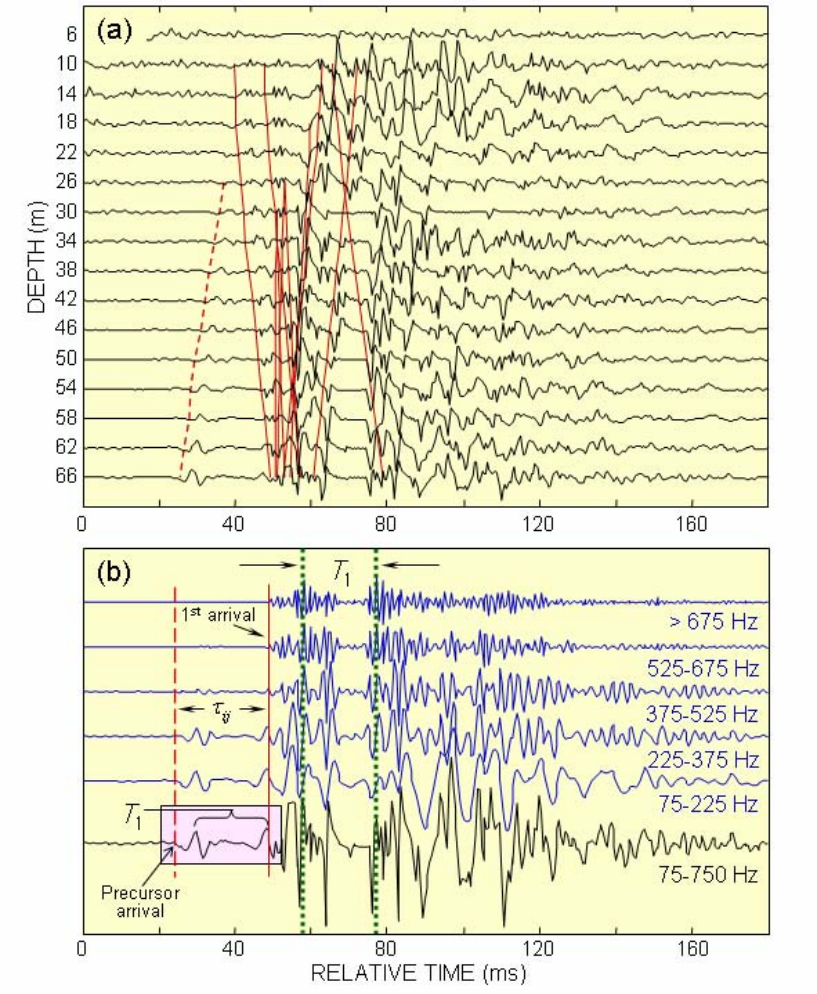

Figure 2. (a) The set 1 arrival structure versus time and depth for 16 channels (top channel at depth 6 m is damaged) and computed arrival time fronts (red, solid lines) corresponding to the first 10 eigenrays. The dashed, red line traces the measured arrival time front of the precursor arrival relative to the first arrival associated with the water borne rays. (b) Narrow band pass outputs for the arrival structure for the 66-m depth hydrophone; shaded area highlights the precursor arrival phase. The two vertical dotted lines correspond to the time interval T_1 between the shock wave and first bubble pulse; τ_{ij} is the arrival difference between the precursor arrival and the first arrival.

IMPACT/APPLICATIONS

Results of this research will constitute an important contribution to WESTPAC data bases. The technical approach refined in this work can be exploited to obtain geoacoustic bottom properties based on logistically simpler, short range measurements.

RELATED PROJECTS

There are no related projects in this fiscal year.

REFERENCES

[1] P. H. Dahl, C. J. Eggen, D. Tang, and R. C. Spindel. *Low-Frequency Sound Propagation in the Yellow Sea; Results from the 1996 China-U.S. Experiment*, Technical report, APL-UW TR 9804, 1998.

[2] J. W. Choi and P. H. Dahl, "First-order and zeroth-order head waves, their sequence, and implications for geoacoustic inversion," *J. Acoust. Soc. Am.*, 119, pp. 3660-3668, June 2006.

PUBLICATIONS

P. H. Dahl and J. W. Choi, "Precursor arrivals in the Yellow Sea, their distinction from first-order head waves, and their geoacoustic inversion," accepted to: *J. Acoust. Soc. Am.*, September 2006.